

QUATERNARY GEOLOGIC MAP OF THE BOSTON 4° × 6° QUADRANGLE, UNITED STATES AND CANADA

**State and Province compilations by
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**Edited and integrated by
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QUATERNARY GEOLOGIC ATLAS OF THE UNITED STATES

NOTE: This map is the product of collaboration between three universities, the Maine Geological Survey, the Geological Survey of Canada, and the U.S. Geological Survey, and is designed for both scientific and practical purposes. It was prepared in two stages. First, separate maps and map explanations of the parts of States and Province included in the quadrangle were prepared by the State and Province compilers. Secondly, these maps were integrated and locally supplemented by the editors; map unit symbols were revised to a uniform symbol of classification, and map unit descriptions were prepared from information received from the compilers and from additional sources. The two diagrams were prepared by Richard M. Pratt. Map and text were reviewed by Byron Stone, U.S. Geological Survey.

Differences in mapping or interpretation in different areas were resolved by correspondence to the extent possible. Most simply reflected differences in available information or in philosophies of mapping, and should encourage further investigation.

For scientific purposes, the map differentiates Quaternary surficial deposits on the basis of lithology, texture, genesis, stratigraphic relationships, and age, as shown on the correlation diagram and indicated in the map unit descriptions. Some geomorphic features, such as end moraines and ice-contact deltas, are distinguished as map units. Stream-cut terraces are not distinguished, and sequences of alluvial or fluvio-glacial deposits cannot be differentiated in the map area at the scale of 1:1,000,000. In deference to R. F. Black (deceased), compiler for Connecticut the inland sequence of moraines of Goldsmith (1982), which Black did not consider to be of glacial origin, are not shown on the map but are outlined on the diagram showing topographically controlled lobate margins of the late Wisconsin Laurentide ice sheet in southeastern New England,

For practical purposes, the map is a surficial materials map. Materials are distinguished on the basis of texture, composition, and local specific characteristics. It is not a map of soils as soils are recognized and classified in pedology. Rather it is a map of soils as recognized in engineering geology, or of subsoils or parent materials from which pedologic and agronomic soils are formed. As a materials map it serves as a base from which a wide variety of derivative maps for use in planning engineering, land use, land management, or water resource projects can be compiled. However, it does not replace detailed site study and analysis.

The map contains illustrations of:

- An index to the International Map of the World 1:1,000,000 Topographic Series showing the location of the Quaternary geologic map of the Boston 4° × 6° quadrangle and other published maps in the Quaternary Geologic Atlas of the United States
- An illustration showing the Areas of Responsibility for compilation of the map with names and organizations of the compilers
- A chart showing the correlation of map units
- An illustration showing topographically controlled lobate margins of late Wisconsin Laurentide ice sheet in southeastern New England
- An illustration showing distribution of glacial drift on the Continental Shelf and in the Gulf of Maine

DESCRIPTION OF MAP SYMBOLS ON PRINTED MAP

CONTACT

ESKER—Direction of transport indicated by chevrons

STRIATIONS—Direction of ice movement indicated by arrow

DRUMLIN

ICE-CONTACT MARINE DELTA—Mapped in Maine only

MINOR WASHBOARD MORAINES

ICE-THRUST MASS

OUTER LIMIT OF GLACIAL ADVANCE—Ticks on side of advance. Dashed where inferred; dotted beneath Atlantic Ocean

ERRATIC BOULDER FAN

MANMADE LAND—Mapped in Boston area only

DESCRIPTION OF MAP UNITS

HOLOCENE

- be BEACH AND DUNE SAND—Beach sand is gray to pale buff, well sorted, medium to coarse; commonly contains scattered shell fragments, seaweed, and, locally, organic and inorganic trash. Sand mostly rounded but includes angular grains, especially near till headlands. Composition mostly quartz, but includes some feldspar and local streaks and thin lenses of dark heavy minerals. Minor components reflect source in glacial and related deposits. Commonly characterized by long continuous gently seaward sloping planar laminae; locally characterized by ripple structures or by shallow channel-and-fill crossbedding. Boulder accumulations locally associated with deposits at till headlands. Sand frequently removed by winter storms exposing underlying boulder beds, till, or bedrock beaches in places; redeposited in summer. Associated dune sand is same as unit **ed**, but all of Holocene age. Commonly present as narrow strips adjacent to and immediately inland from beach sand; cannot be separately mapped at map scale. Both beach and dune sand deposits generally active at present. Thickness of beach sand 1-3 m; dune sand 1-5 m

HOLOCENE AND LATE WISCONSIN

- hs SWAMP DEPOSIT—Dark-brown to black muck, mucky peat, peat, and organic residues mixed with fine-grained mineral sediment. Occurs in ice-block depressions, abandoned glacial meltwater channels, and in basins dammed by glacial deposits. Fibrous peat present locally in ice-block depressions and small glacial lake basins where it commonly overlies lake silt and clay (**lca**). Thickness generally 1-3 m rarely more than 5 m
- hps SALINE MARSH AND ESTUARINE PEAT AND CLAY—Brown or brownish-gray to gray or black peat and clay, intertongued and interbedded. Dominated by *Spartina alterniflora* in areas flooded by every high tide and by *Spartina patens* in the higher intertidal marsh zone. Commonly mixed with silt, clay, and sand. Thickness 1-10 m
- ag ALLUVIUM—Gray, locally oxide or manganese coated pebbles, cobbles, and boulders in a matrix of yellowish-brown, brown, or gray sand and some silt. Noncalcareous; poorly to well sorted, poorly to well stratified; commonly crossbedded or with cut-and-fill structure. Texture varies laterally and vertically. Upper part commonly includes more sand and silt than lower part. Clasts rounded to subangular mostly of igneous and metamorphic rock types. Occurs in stream channels and underlies flood plains, stream terraces, and alluvial fans. Mapped areas may include some outwash gravel or ice-contact deposits. Thickness variable; commonly 1-5 m, but locally more than 10 m
- al ALLUVIUM—Yellowish-brown, reddish-brown, brown, olive, gray, or mottled sand and silt; locally includes minor gravel. Poorly to well sorted. Poorly to well stratified; commonly with cut-and-fill channel crossbedding. Textures vary laterally and vertically. Upper part mostly coarse to fine sand and a little silt; lower part commonly sand and gravel, in places cobble or boulder gravel. Lithologic composition reflects that of local glacial deposits and bedrock. Underlies flood plains, low stream terraces, and alluvial fans. Mapped only locally, but narrow deposits commonly present in areas mapped as outwash sand and gravel (**gg**) or ice-contact sand and gravel (**kg**). Mapped areas commonly include thin peat and swamp deposits. Thickness variable; generally 1-5 m, but in places as thick as 10 m
- es EOLIAN SAND—Yellowish-brown, pale-brown, or yellowish-gray medium to fine sand, locally silty. Well sorted; generally massive; locally crossbedded; weakly calcareous to noncalcareous. Sand mostly angular to rounded quartz grains, some frosted. Commonly occurs on or adjacent to areas of outwash sand and gravel (**gg**). Mapped only in Maine, but present on east side of Merrimack River valley in New Hampshire, on sea cliffs of Cape Cod and offshore islands in Massachusetts, and as an irregular, patchy blanket in swales and on lea slopes of irregular terrain near source areas in Rhode Island and Connecticut. Thickness 1-3 m
- ed DUNE SAND—Pale-brown to gray well-sorted medium to coarse sand, chiefly quartz but includes some feldspar and heavy minerals; grains round to subround, commonly frosted. Locally contains a few scattered ventifacts. Forms massive irregular dunes, foredunes, or parabolic dunes. Small longitudinal and transverse dunes also present in a few places. Mapped only on Cape Cod and locally in Maine. Dune height ranges from 2 to 30 m

LATE WISCONSIN

- lca LAKE SILT AND CLAY—Yellowish-brown or brown to reddish-brown, olive to bluish-gray, or gray silt and clay. Local thin beds of fine sand. Predominantly thinly laminated; locally varved. In places stony or interbedded with sand; locally includes bodies of till. Most deposits underlie flat, low areas or valley floors formerly occupied by glacial lakes; some adjacent to or surrounded by ice-contact deposits. Mapped areas commonly include overlying eolian sand and silt peat, swamp deposits, or alluvium. Thickness generally 1-10 m; rarely more than 25 m
- lsa LAKE SAND—Pale-yellow, yellowish-brown or gray medium to coarse sand; moderately to well sorted, moderately to well stratified; mostly flat bedded; includes scattered pebbles and local lenses of pebble to cobble gravel. Sand chiefly quartz and feldspar, clasts chiefly hard igneous and metamorphic rocks. Mostly in upper sector of Merrimack River valley in New Hampshire. Thickness 5-30 m
- mc MARINE SILT AND CLAY (part of Presumpscot Formation in Maine; unnamed in New Hampshire and northeastern Massachusetts; "Boston blue clay" in Boston area)—Yellowish-brown, reddish-brown, or brown, bluish-gray or dark-gray, fine silt and soft clay containing minor fine sand laminae. Locally, banding reflects colors of source bedrock. Generally calcareous; locally noncalcareous. Commonly massive and structureless; locally horizontally bedded. Intertongues with marine sand and gravel (**ms**) in places. Dropstones common locally; in places fossiliferous. Deposits mostly in valleys. Mapped areas include areas of till (**ts**) that commonly underlies the silt and clay and projects upward through it; mapped areas also include small overlying deposits of peat, eolian sand, and alluvium. Thickness 5-30 m
- ms MARINE SAND AND GRAVEL (part of Presumpscot Formation in Maine; unnamed in New Hampshire and northeastern Massachusetts)—Pale-olive, brown, and yellowish-brown, very fine to coarse sand; massive to well stratified, evenly bedded. Locally grades into near-shore sand and gravel. Locally fossiliferous. Mapped areas include small marine ice-contact delta deposits (**mkd**); in places areas of the underlying till (**ts**) project upward through the sand, and small areas of overlying eolian sand and alluvium. Thickness 5-8 m
- mkd MARINE ICE-CONTACT DELTA SAND AND GRAVEL—Grayish-brown, pale-blue, or pale-yellow pebble and cobble gravel and sand; well stratified, foreset bedded, moderately well sorted. Clasts well rounded; composed of hard igneous and metamorphic rocks. Topset beds chiefly gravel; foreset beds mixed sand and gravel. Mapped only in coastal New Hampshire and northeastern Massachusetts; shown by symbol in Maine. Thickness as much as 40 m
- gg OUTWASH SAND AND GRAVEL—Pale-yellow, yellowish-brown, grayish-brown, or gray, fine to coarse sand or pebbly sand alternating with layers of granule- to cobble-gravel and minor beds of silt; locally bouldery. Clasts generally subrounded to well rounded. Texture varies laterally and vertically. Crudely to well bedded; moderately well to well sorted within beds. Commonly flat bedded or channel-and-fill crossbedded; in places foreset bedded. Clasts chiefly hard igneous and metamorphic rocks. Underlies terraces, outwash plains, valley trains, fans, and meltwater-channel fills. Surface locally pitted with small to large ice-block depressions, and locally strewn with boulders. Mapped areas commonly include small deposits of ice-contact sand and gravel, lacustrine deposits, swamp deposits, peat, alluvium, eolian sand, or marine silt and clay. Thickness generally 1-10 m; rarely as much as 60 m
- ggl OUTWASH SAND AND GRAVEL AND UNDERLYING LAKE DEPOSITS—Pale-yellow, yellowish-brown, reddish-brown or brownish-gray, medium to coarse sand and pebble to cobble gravel, locally bouldery. Clasts subrounded to well rounded, chiefly of hard igneous and metamorphic rocks; sand moderately to well sorted, moderately to well stratified, chiefly quartz and feldspar; flat bedded, channel-and-fill crossbedded or foreset bedded. Surface commonly strewn with boulders and locally pitted with ice-block depressions. Underlying lake deposits mostly fine to medium sand, chiefly flat bedded, locally lenticularly crossbedded, current-ripple bedded or foreset bedded, with interbeds of massive to laminated, locally varved, silt and clay that tend to become more abundant downward. In southeastern Massachusetts and on Cape Cod, the upper sand and gravel may represent delta topset outwash plains. On Cape Cod, the underlying lake beds locally contain carbonized wood, marine shells, and sharks teeth, the latter reworked from underlying Cretaceous beds, and a few deep pits and well records show that the flat-bedded lake deposits locally overlie large-scale deltaic foreset beds. Mapped areas commonly include small deposits of overlying eolian sand, peat, or alluvium. Thickness of outwash sand and gravel 5-10 m; underlying lake deposits 5-30 m

- gsl OUTWASH SAND AND UNDERLYING LAKE DEPOSITS—Pale-yellow, yellowish-brown, reddish-brown or brownish-gray medium to coarse sand with sparse scattered pebbles and local lenses of gravel. Sand moderately to well sorted; chiefly quartz and feldspar; flat bedded, channel-and-fill crossbedded, or foreset bedded. Underlying lake deposits chiefly flat bedded, lenticularly crossbedded, or ripple-bedded medium to fine sand and laminated or varved silt and clay. Mapped chiefly in Merrimack River valley in New Hampshire, on Cape Cod in Massachusetts, and at the head of Narragansett Bay in Rhode Island. Thickness of outwash sand 5-10 m; underlying lake deposits 5-30 m
- kg ICE-CONTACT SAND AND GRAVEL—Yellowish-brown, reddish-brown, brownish-gray, or gray, fine to coarse sand and gravel containing minor beds of silt and clay, and local lenses or masses of till or flowtill. Poorly to well sorted; poorly to well stratified. Inward from ice-contact slopes, commonly characterized by distorted bedding, high-angle faults, folds, and slump or collapse structures. Bedding thin to thick, flat bedded, channel-and-fill crossbedded, foreset bedded. Beds commonly discontinuous horizontally. Textures vary laterally and vertically. Clasts range from granules to boulders, angular to well rounded, and are chiefly of hard igneous and metamorphic rocks. Smaller clasts generally of local bedrock; some large cobbles and boulders may be erratics. Underlies kame terraces and forms complexes of crevasse fillings, eskers, mounds, and hummocks in valleys. Inferred to have been deposited against irregular remnants of stagnant ice; ice-contact headward slopes of kame terraces inferred to mark successive ice-marginal positions. Surface locally pitted with ice-block depressions, and in places strewn with boulders. Mapped areas may include small deposits of alluvium, outwash sand and gravel, lake silt and clay, eolian sand, peat, or swamp deposits. Thickness 5-20 m
- kd ICE-CONTACT DELTA SAND AND GRAVEL—Pale-yellow, yellowish-brown, reddish-brown, brownish-gray, or gray sand and pebble- or cobble-gravel; clasts subrounded to well rounded; sand moderately well to well sorted, well stratified. Topset beds, mostly pebble and cobble gravel, sand, and minor silt; foreset beds, sand and sparse gravel; bottomset beds, flat-bedded silt and clay. Clasts chiefly hard igneous and metamorphic rocks. Characterized by steep headward and locally lateral ice-contact slopes inward from which bedding commonly displays collapse, slump, and fault structures. Most ice-contact deposits are in valleys, but some are perched on terrain above the valley floor. They are inferred to have been deposited at successive ice marginal positions by streams flowing from stagnant ice into ice-marginal lakes or ponds. Thickness 5-15 m; locally as much as 40 m
- SANDY TILL—Yellowish-brown, brown to grayish-brown, olive, or pink to reddish-gray till. Locally weakly calcareous to noncalcareous, reflecting composition of source materials. Texture highly variable, stony sand to stony sandy loam; locally dense, fissile silty clay with boulders. Mostly nonsorted to poorly sorted, but well sorted in small lenses. Generally friable, lacking fissility; loose to moderately compact. Commonly gravelly, cobbly, bouldery, or rubbly. Clasts angular to rounded. Rock types reflect local bedrock which changes markedly over relatively short distances; lithologies chiefly granite, pegmatite, rhyolite, granodiorite, diorite, gabbro, diabase, basalt, gneiss, crystalline schist, slaty schist, phyllite, slate, graywacke, argillite, quartzite, and sandstone. The sandy till at the surface, or "upper till," locally overlies a "lower till," not separately mapped, which is dark gray brown or dark gray and more clayey, more compact, and less bouldery than the "upper till." The "lower till" is commonly present beneath "upper till" in drumlins. The "upper till" forms ground moraine, which varies greatly in thickness but is rarely very thick, and attenuated drift, which is very thin and discontinuous with intervening areas of glaciated bedrock. Both ground moraine and attenuated drift widespread throughout New England; both are included in map unit **ts** except in Maine where they are mapped separately (**ts**, **tsr**). Mapped areas locally include small deposits of outwash sand and gravel, ice-contact sediments, lake sediments, marine sediments, alluvium, peat, swamp deposits, or eolian sand
- ts Ground moraine—Thickness generally 1.5-4 m; rarely more than 10 m
- ts End moraine—Narrow to broad, well-defined ridges, chiefly till, but includes local lenses of stratified sediments. Surface commonly bouldery. Mapped only on Fishers Island, New York, and on Block Island, Rhode Island. Thickness 5-15 m
- tsr Attenuated drift—Thin, discontinuous deposits of sandy till separated by numerous or extensive bedrock outcrops, on which are scattered erratics. Thickness generally 0.5-2 m

- TILL AND MARINE DEPOSITS UNDIVIDED**—Till, similar to unit **ts**, but mapped areas include numerous small deposits, or locally a thin mantle, of marine silt and clay or marine sand and gravel. Till generally constitutes 80-95 percent of mapped area. Commonly, marine clay present in central parts of valleys, and marine sand and gravel as narrow beach deposits along valley slopes. Mapped areas locally include outwash sand and gravel, ice-contact sand and gravel, alluvium, swamp deposits, or peat
- tm Ground moraine—Thickness generally 0.5-4 m; locally as much as 10 m
- tmr Attenuated drift—Thin discontinuous deposits of sandy till and local small marine deposits separated by numerous or extensive bedrock outcrops on which are scattered erratics. Mapped only in Maine. Thickness 0.5-2 m
- ke **KAME MORaine**—Dark- to light-gray or pale-yellow to yellowish-brown loose sandy till several meters thick underlain by sand and gravel that locally includes masses of lake silt and clay or sandy loamy till. Forms end moraine ridges as long as 20 km and as high as 10-20 m in southern Rhode Island and southeastern Massachusetts (Cape Cod, Martha's Vineyard, and Nantucket Island). Locally, the surface sandy till is lacking. Clasts in gravel subrounded to rounded and mostly of granite, gneiss, and schist. Sand coarse to fine, poorly to well sorted, locally foreset bedded, and mostly of quartz and feldspar. Included masses of till and silty to clayey lake deposits. On Block Island, Martha's Vineyard, and Cape Cod, includes imbricate, ice-thrust masses of early Wisconsin till and stratified drift. Ice-thrust masses (**IT**) can be shown at map scale only on Martha's Vineyard. Sediments of Miocene and Cretaceous age included in ice-thrust masses at Gay Head Light on Martha's Vineyard. Mapped areas of kame moraine include small overlying deposits of peat, lake silt and clay, swamp deposits, and a persistent, thin mantle of eolian sand. Thickness 5-80 m
- tx **SANDY TO CLAYEY TILL**—Yellowish-brown, brown, and gray, calcareous fine sand to clay. Texture may vary markedly in short distances. Generally loose, locally very compact, poorly sorted. Pebbly to very pebbly; locally gravelly. Cobbles and boulders common; locally very bouldery. Clasts chiefly erratic crystalline igneous and metamorphic rocks. Discontinuous laterally. Mapped only on Long Island. Mapped areas locally include small areas of outwash gravel, ice-contact sand and gravel, alluvium, dune sand, or loess. Thickness 0.5-1.5 m

LATE WISCONSIN AND EARLY WISCONSIN

- txa **SANDY TO CLAYEY TILL**—Complex deposit of late Wisconsin sandy to clayey till (**tx**) and early Wisconsin clayey till (Montauk Till) on Long Island, Block Island, and Nantucket Island. Late Wisconsin till is thin and early Wisconsin till is at surface in much of area on Long Island. On Block Island and Nantucket Island, early Wisconsin till exposed only in coastal bluffs. Both tills discontinuous. Early Wisconsin till is red, reddish-brown, brown, or gray, calcareous clay and clay loam. Incorporated in it are lenses and masses of lake and marine clay and silt; also commonly interbedded with flowtill and with lake sand, silt and clay. Deposit compact; locally weakly stratified; contains flow structures and shear planes locally; inferred to have been deformed by late Wisconsin ice shove. Generally pebble free or sparingly pebbly; rare cobbles and boulders. Clasts chiefly erratic crystalline igneous and metamorphic rocks. Thickness 3-5 m; locally more than 10 m

SANGAMON

- mse MARINE FOSSILIFEROUS SAND, SILT, CLAY, AND GRAVEL (Sankaty Sand on Martha's Vineyard)
—Dark- to light-gray, weathering yellowish-brown, locally red, fossiliferous marine sand; poorly to well sorted. Includes two units separated by an unconformity. Upper unit overlain by a yellowish- white, well-sorted, planar and crossbedded sand entrenched by channels as deep as 10 m. Channels are filled with kame moraine deposits (**ke**) that extend laterally from the channels over the upper unit. Upper unit involuted and ice thrust; includes an upper, poorly sorted, silty sand containing blue mussel shells and shell fragments, a middle ferruginous medium to coarse sand, and a basal clean sand and gravel containing abundant hardshell clams. Upper unit separated from lower unit by an unconformity along which are wind-polished stones. Lower unit includes a bioturbated sand and a basal gravel; sand contains an abundant hardshell molluscan fauna (many in articulated growth position) and a serpulid bed. Lower unit overlies sand, silt, flowtill, and stone-poor till of an earlier glaciation considered Illinoian or older in age. Fauna in the Sankaty Sand indicates that climate during deposition was as warm as or slightly warmer than at present. A U-series age of $\geq 133,000$ B.P. has been obtained from shell material in the sand. Thickness ranges from from 2 to 15 m (upper and lower marine units)

PLIOCENE AND OLDER CENOZOIC

- ugg GLACIATED GRANITIC GRUS—Light- to dark-brown or reddish-brown, coarse granitic grus; overlain locally by patches of thin sandy till, sand, and widely scattered glacial pebbles, cobbles, and boulders from local and distant sources. The grus is a loose aggregate of feldspar, quartz, and biotite or muscovite mica resulting from pre-glacial disintegration of coarse granite along intercrystal faces and cleavage planes. Commonly, it extends into underlying bedrock along joint planes and around jointblock core boulders. At one Rhode Island locality, angular blocks of grus in the base of the overlying sandy till, only a few centimeters from like cavities in the grus surface, suggest that the grus was frozen when glacial extraction of the blocks took place. Grus is developed in coarse mafic rocks as well as in granite at a number of small localities throughout New England, but areas extensive enough to show at map scale are known only in Rhode Island. Remnant thickness 0.5-3 m

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